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Simple Additive Weighting (SAW) method in Determining Beneficiaries of Foundation Benefits

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ABSTRACT

In this study, a case will be raised, namely looking for the best alternative based on the criteria determined by the foundation using the SAW (Simple Additive Weighting) method. The research was conducted by looking for the weight value for each attribute, then a ranking process was carried out which would determine the optimal alternative, namely the right student to receive foundation compensation. With this research, it is possible to find out the terms or criteria needed in proposing beneficiaries of foundation compensation, such as the criteria seen from the amount of income of the parents of students, the status of students in the family, the number of dependents of the parents of students, and student achievements or champions.

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1. INTRODUCTION

MDTA Nurul Ikhwan Foundation is one of the foundations that has made the activity of providing compensation to underprivileged students in the family economy and orphans into a habit every year with a predetermined allocation of funds. The foundation is providing compensation to students every year is carried out with a direct system of paying monthly tuition fees and data collection is still carried out in recording in the ledger so that it is less effective and efficient in its implementation. Data collection that has not used a computerized or manual data collection system creates difficulties such as in selecting students who receive compensation alternately each year by allocating compensation funds that will be given to 10% of the total number of students per class per year with the allocated funds.

The problem of decision making is a form of selecting from various alternative actions that may be selected through a certain mechanism in the hope of producing the best decision. By determining the best decision, several methods can be used to build a decision support system, one of which is Simple Additive Weighting (SAW)[1]. The SAW method is a method used in dealing with situations of Fuzzy Multiple Attribute Decision Making (FMADM) or decision making by finding the optimal alternative from a number of alternatives with certain criteria[2].

The Simple Additive Weighting (SAW) method is known as the weighted addition method. Basically, the SAW work concept is to find the weighted sum of the performance of each alternative on all attributes. The total score for the alternatives is obtained by adding up all the multiplication

results between the rating (which can be compared across attributes) and the weight of each attribute. The rating of each attribute must be dimension-free in the sense that it has passed the previous matrix normalization process[3]. In a previous study entitled Designing a Decision Support System for Scholarship Recipients using the SAW (Simple Additive Weighting) Method, it was stated that the determination of the scholarship would be right on target by carrying out clear calculations according to valid criteria[1]. With an application made with the Matlab programming language for testing the SAW method, it can help decision-makers inputting participant scores[4][5].

2. RESEARCH METHOD

In carrying out this research, clear and structured stages are needed, in order to facilitate the process, it is necessary to make a diagram design such as the diagram below:

Figure 1. Diagram of Methods and Research Stages

In the stages of the research method, the author conducted interviews with experts to obtain symptoms of worms in livestock.

2.1. Basic theory

A. Fuzzy Multiple Attribute Decision Making (FMADM)

Fuzzy Multiple Attribute Decision Making (FMADM), is a method used to find optimal alternatives from many alternatives with certain criteria. The essence of FMADM is to determine the weight value for each attribute, then proceed with a ranking process that will select the alternatives that have been given[6]. There are 2 approaches to finding the attribute weight value, namely subjective and objective approaches. Each approach has advantages and disadvantages. In the subjective approach, the weight value is determined based on the subjectivity of the decision-maker, so that several factors in the alternative ranking process can be determined independently[7]. Whereas in the objective approach, the weight value is calculated mathematically so that it ignores the subjectivity of the decision-maker.

There are several methods that can be used to solve FMADM problems, including:

1. Simple Additive Weighting (SAW).
2. Weighted Product (WP).
3. ELECTRE.
4. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).
5. Analytic Hierarchy Process (AHP).

B. Simple Additive Weighting (SAW)

The Simple Additive Weighting (SAW) method is often known as the weighted addition method. The basic concept of the SAW method is to find a weighted sum of the performance ratings for each alternative on all attributes (Fishburn, 1967) (MacCrimmon, 1968). The SAW method requires a decision matrix normalization process (X) to a scale that can be compared with all existing alternative ratings[8].

This SAW method requires the decision-maker to determine the weight for each attribute. The total score for the alternatives is obtained by adding up all the multiplication results between the rating (which can be compared across attributes) and the weight of each

attribute. The rating of each attribute must be dimension-free in the sense that it has passed the previous matrix normalization process[9].

The steps for completing the SAW are as follows:

a. Determine the criteria that will be used as a reference in making decisions, namely Ci.
b. Determine the suitability rating of each alternative for each alternative.
c. Making a decision matrix based on the criteria (Ci), then normalizing the matrix based on the equation adjusted for the type of attribute (profit attribute or cost attribute) in order to obtain a normalized matrix R.
d. The final result is obtained from the ranking process, namely the addition and multiplication of the normalized matrix R with the weight vector so that the largest value is chosen as the best alternative (Ai) as a solution.

The formula for carrying out the normalization is as follows[7]:

$$R_{ij} = \begin{cases} \dfrac{X_{ij}}{\max X_{ij}} & \text{If j is the benefit attribute} \\ \dfrac{\min X_{ij}}{X_{ij}} & \text{If j is the cost attribute} \end{cases}$$

Where R_{ij} is a normalized performance rating; X_{ij} is the attribute value of each criterion; Max X_{ij} is the greatest value of each criterion; Min X_{ij} is the smallest value of each criterion; Benefit is the greatest value is the best; Cost is the smallest value is the best. Rij is the normalized performance rating of the alternatives Ai on attribute Cj; i = 1,2,…, m and j = 1,2,…, n.

The preference value for each alternative (Vi) is given as:

$$V_i = \sum_{j=1}^{n} w_j R_{ij}$$

Where V_i is the ranking for each alternative, W_j is the weighted value of each criterion; R_{ij} is the normalized performance rating value. A larger V_i value indicates that the alternative Ai is preferred.

3. RESULTS AND DISCUSSION

In determining students who are entitled to receive compensation at the MDTA Nurul Ikhwan Foundation, namely schools / foundations that select students and who are entitled to become students who receive compensation for the foundation for the annual period with predetermined criteria. One of the solutions to the FMADM problem, criteria and weights are needed in doing the calculations so that the best alternative will be obtained are as follows:

1. Determining each of each criterion can be seen in table 1:

Table 1.Codes and criteria provisions

Kode	Kriteria	Atribut
C1	Jumlah penghasilan orang tua	*Benefit* (keuntungan)
C2	Status dalam keluarga	*Benefit* (keuntungan)
C3	Jumlah tanggungan orang tua	*Cost (*biaya)
C4	Prestasi siswa (juara)	*Benefit* (keuntungan)

2. Furthermore, the decision maker gives preference weights for each criterion as W shown in table 2:

Table 2.Determination of W Value

Kriteria	Range (%)	Bobot
C1	40	0,40
C2	25	0,25
C3	20	0,20

C4	15	0,15

From each of these criteria the weights will be determined. The weight consists of six fuzzy numbers, namely very low (SR), low (R), medium (S), high (T), and very high (ST) as shown in Figure 2:

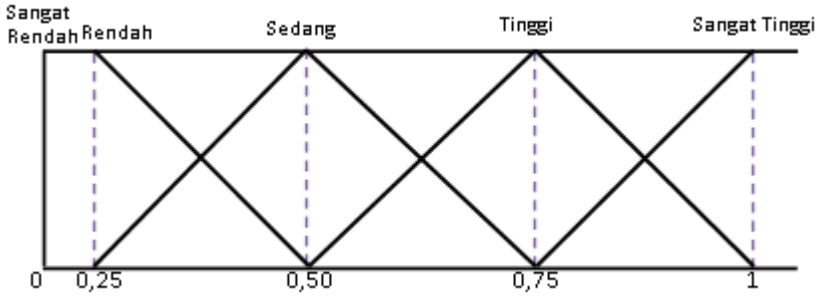

Figure 2. Weight criteria

From each of these weights, a variable will be converted into a fuzzy number using the formula, the n / n-1 variable.

Table 3.Variables and Weights (Value)

Variabel	Bobot (Nilai)
Sangat Rendah (SR)	Variabel ke-0/ (5-1) = 0/4 = 0
Rendah	Variabel ke-1/ (5-1) = 1/4 = 0,25
Sedang (S)	Variabel ke-2 / (5-1) = 2/4 = 0,50
Tinggi (T)	Variabel ke-3 / (5-1) = 3/4 = 0,75
Sangat Tinggi (ST)	Variabel ke-4 / (5-1) = 4/4 = 1

The fuzzy weighting is as follows:

1. The criteria for the amount of parents income.

Table 4.Determining criteria for parents income

Penghasilan orang tua (C1)	Variabel	Nilai
C1<= Rp 500.000	Sangat Tinggi	1
C1> Rp 500 ribu <C1<=Rp 1 juta	Tinggi	0,75
C1> Rp 1 juta <C1<=Rp 1,5 juta	Sedang	0,50
C1> Rp 1,5 juta <C1<=Rp 2,5 juta	Rendah	0,25
C1> Rp 2,5 juta	Sangat Rendah	0

2. Criteria for status in the family

Table 5.Criteria for status in the family

Status dalam keluarga (C2)	Variabel	Nilai
Anak Yatim Piatu	Sangat Tinggi	1
Anak Yatim	Tinggi	0,75
Anak Piatu	Sedang	0,50

3. The criteria for the number of dependents of the parents

Table 6.Criteria for the number of dependents of parents

Jumlah tanggungan orang tua (C3)	Variabel	Nilai
1 anak	Sangat Rendah	0
2 anak	Rendah	0,25
3 anak	Sedang	0,50
4 anak	Tinggi	0,75
Lebih dari 4 anak	Sangat Tinggi	1

4. Student achievement criteria (champion)

Table 7.Student achievement criteria / champions

Prestasi siswa/Juara (C4)	Variabel	Nilai
Juara 1	Sangat Tinggi	1

Juara 2	Tinggi	0,75
Juara 3	Sedang	0,50
Juara 4	Rendah	0,25
Juara 5	Sangat Rendah	0

The data on the results of student selection submitted in receiving foundation compensation can be seen in table 8 below:

Table 8.Student data submitted

No	Alternatif	Kriteria			
		Jumlah penghasilan orang tua	status dalam keluarga	Jumlah tanggungan orang tua	Prestasi siswa/ juara
1	A_1	Rp 500.000	Yatim	3 anak	Juara 2
2	A_2	Rp 800.000	Piatu	2 anak	Juara 4
3	A_3	Rp 1.000.000	Yatim Piatu	4 anak	Juara 1
4	A_4	Rp 1.400.000	Piatu	3 anak	Juara 3
5	A_5	Rp 2.500.000	Yatim	4 anak	Juara 2

The sample above is data from students who become alternatives, namely, A1 (Farhan Rifai), A2 (Syashi Ajeng Sachira), and A3 (Sidratul Muntaha), A4 (Aqila Zahra Daulay), and A5 (Alif Putra Kelana).

The suitability rating data of each alternative can be seen in table 9 below:

Table 9.Suitability Rating of Each Alternative on Each Criterion

No	Alternatif	Kriteria			
		Jumlah penghasilan orang tua	status dalam keluarga	jumlah tanggungan orang tua	prestasi siswa/ juara
1	A_1	1	0,75	0,50	0,75
2	A_2	0,75	0,50	0,25	0,25
3	A_3	0,75	1	0,75	1
4	A_4	0,50	0,50	0,50	0,50
5	A_5	0,25	0,75	0,75	0,75

Matriks keputusan dibentuk dari tabel kecocokan sebagai berikut:

$$X = \begin{pmatrix} 1 & 0.75 & 0.50 & 0.75 \\ 0.75 & 0.50 & 0.25 & 0.25 \\ 0{,}75 & 1 & 0{,}75 & 1 \\ 0.50 & 0.50 & 0.50 & 0.50 \\ 0{,}25 & 0{,}75 & 0{,}75 & 0{,}75 \end{pmatrix}$$

First of all, the X matrix normalization is carried out:

1. The amount of parental income is included in the benefit attribute.

   So:

   $$R_{11} = \frac{1}{\text{Max}\{1;\ 0{,}75;\ 0{,}75;\ 0{,}50;\ 0{,}25\}} = \frac{1}{1} = 1$$

   $$R_{12} = \frac{0{,}75}{\text{Max}\{1;\ 0{,}75;\ 0{,}75;\ 0{,}50;\ 0{,}25\}} = \frac{0{,}75}{1} = 0{,}75$$

   $$R_{13} = \frac{0{,}75}{\text{Max}\{1;\ 0{,}75;\ 0{,}75;\ 0{,}50;\ 0{,}25\}} = \frac{0{,}75}{1} = 0{,}75$$

   $$R_{14} = \frac{0{,}50}{\text{Max}\{1;\ 0{,}75;\ 0{,}75;\ 0{,}50;\ 0{,}25\}} = \frac{0{,}50}{1} = 0{,}50$$

   $$R_{15} = \frac{0{,}25}{\text{Max}\{1;\ 0{,}75;\ 0{,}75;\ 0{,}50;\ 0{,}25\}} = \frac{0{,}25}{1} = 0{,}25$$

2. For status in the family, it is included in the benefit attribute.

   So:

   $$R_{21} = \frac{0{,}75}{\text{Max}\{0{,}75;0{,}50;1;0{,}50;0{,}75\}} = \frac{0{,}75}{1} = 0{,}75$$

$$R_{22}=\frac{0{,}50}{\text{Max}\{0{,}75;0{,}50;1;0{,}50;0{,}75\}}=\frac{0{,}50}{1}=0{,}50$$
$$R_{23}=\frac{1}{\text{Max}\{0{,}75;0{,}50;1;0{,}50;0{,}75\}}=\frac{1}{1}=1$$
$$R_{24}=\frac{0{,}50}{\text{Max}\{0{,}75;0{,}50;1;0{,}50;0{,}75\}}=\frac{0{,}50}{1}=0{,}50$$
$$R_{25}=\frac{0{,}75}{\text{Max}\{0{,}75;0{,}50;1;0{,}50;0{,}75\}}=\frac{0{,}75}{1}=0{,}75$$

3. The number of parent's dependents is included in the cost attribute.
   So:

$$R_{31}=\frac{\text{Min}\{1;\,0{,}75;\,0{,}75;\,0{,}50;\,0{,}25\}}{0{,}50}=\frac{0{,}25}{0{,}50}=0{,}5$$
$$R_{32}=\frac{\text{Min}\{1;\,0{,}75;\,0{,}75;\,0{,}50;\,0{,}25\}}{0{,}25}=\frac{0{,}25}{0{,}25}=1$$
$$R_{33}=\frac{\text{Min}\{1;\,0{,}75;\,0{,}75;\,0{,}50;\,0{,}25\}}{0{,}75}=\frac{0{,}25}{0{,}75}=0{,}333$$
$$R_{34}=\frac{\text{Min}\{1;\,0{,}75;\,0{,}75;\,0{,}50;\,0{,}25\}}{0{,}50}=\frac{0{,}25}{0{,}50}=0{,}5$$
$$R_{35}=\frac{\text{Min}\{1;\,0{,}75;\,0{,}75;\,0{,}50;\,0{,}25\}}{0{,}75}=\frac{0{,}25}{0{,}75}=0{,}333$$

4. Student achievement / champion is included in the benefit attribute.
   So:

$$R_{21}=\frac{0{,}75}{\text{Max}\{0{,}75;0{,}50;1;0{,}50;0{,}75\}}=\frac{0{,}75}{1}=0{,}75$$
$$R_{22}=\frac{0{,}25}{\text{Max}\{0{,}75;0{,}50;1;0{,}50;0{,}75\}}=\frac{0{,}25}{1}=0{,}25$$
$$R_{23}=\frac{1}{\text{Max}\{0{,}75;0{,}50;1;0{,}50;0{,}75\}}=\frac{1}{1}=1$$
$$R_{24}=\frac{0{,}50}{\text{Max}\{0{,}75;0{,}50;1;0{,}50;0{,}75\}}=\frac{0{,}50}{1}=0{,}50$$
$$R_{25}=\frac{0{,}75}{\text{Max}\{0{,}75;0{,}50;1;0{,}50;0{,}75\}}=\frac{0{,}75}{1}=0{,}75$$

So that the R matrix is obtained as follows:

$$\text{R}=\begin{pmatrix}1 & 0{,}75 & 0{,}5 & 0{,}75\\ 0{,}75 & 0{,}50 & 1 & 0{,}25\\ 0{,}75 & 1 & 0{,}333 & 1\\ 0{,}50 & 0{,}50 & 0{,}5 & 0{,}50\\ 0{,}25 & 0{,}75 & 0{,}333 & 0{,}75\end{pmatrix}$$

The ranking process is obtained based on the following equation:

$$V_i = \sum_{j=1}^{n} w_j\, r_{ij}$$

The ranking process is carried out with the weighting equation of the W criterion, where a larger V_i value indicates that the alternative A_i is preferred. Then, the weight vector W = (0.40; 0.25; 0.20; 0.15).

$\text{V}_1 = (0{,}40\ \text{X}\ 1) + (0{,}25\ \text{X}\ 0{,}75) + (0{,}20\ \text{X}\ 0{,}5) + (0{,}15\ \text{X}\ 0{,}75) = 0{,}8$
$\text{V}_2 = (0{,}40\ \text{X}\ 0{,}75) + (0{,}25\ \text{X}\ 0{,}50) + (0{,}20\ \text{X}\ 1) + (0{,}15\ \text{X}\ 0{,}25) = 0{,}6625$
$\text{V}_3 = (0{,}40\ \text{X}\ 0{,}75) + (0{,}25\ \text{X}\ 1) + (0{,}20\ \text{X}\ 0{,}333) + (0{,}15\ \text{X}\ 1) = 0{,}7666$
$\text{V}_4 = (0{,}40\ \text{X}\ 0{,}50) + (0{,}25\ \text{X}\ 0{,}50) + (0{,}20\ \text{X}\ 0{,}5) + (0{,}15\ \text{X}\ 0{,}50) = 0{,}5$
$\text{V}_5 = (0{,}40\ \text{X}\ 0{,}25) + (0{,}25\ \text{X}\ 0{,}75) + (0{,}20\ \text{X}\ 0{,}333) + (0{,}15\ \text{X}\ 0{,}75) = 0{,}4666$

The value of the ranking calculation for each alternative with a value of V_i can be seen in table 10

Table 10.Ranking Calculation Results

Alternatif	V_i	Rangking
A1	0,8	1

A2	0,6625	3
A3	0,7666	2
A4	0,5	4
A5	0, 4666	5

From the above calculations, the first order is Farhan Rifai with a value of 0.8; second place is Sidratul Muntaha with a value of 0.7666; Syashi Ajeng Sachira with a value of 0.6625; fourth place is Aqila Zahra Daulay with a value of 0.5 and the last order is Alif Putra Kelana with a value of 0.4666. Based on the results of the calculations and the results of the order received to become students who receive compensation for the foundation for the annual period, the preferences with the greatest value are A1 and A3, namely Farhan Rifai and Sidratul Muntaha.

4. CONCLUSION

With this research, it is possible to find out the terms or criteria needed in proposing beneficiaries of foundation compensation, such as the criteria seen from the amount of income of the parents of students, the status of students in the family, the number of dependents of the parents of students, and student achievements or champions. By applying the SAW (Simple Additive Weighting) method, results in the value of the determination of the criteria, weighting, suitability rating, normalization, and ranking so as to produce the value of each criterion.

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